# Charles Darwin University

Final Examination

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| Family Name | | | | | | |
| Given Name/s | | | | | | |
| Student Number | | | | | | |
| Teaching Period | Semester 2, 2018 | | | | | |

| ENG338 – Machine Design Principles | DURATION | |
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| | | |
| | Reading Time: | 10 minutes |
| | Writing Time: | 180 minutes |
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**INSTRUCTIONS TO CANDIDATES**

The exam has 5 questions and you must answer any **four of the five** questions. The exam is for 100 marks. Each question carries 25 marks. Suggested time for each question is 45 minutes.

**EXAM CONDITIONS**

You may begin writing from the commencement of the examination session. The reading time indicated above is provided as a guide only.

This is a RESTRICTED OPEN BOOK examination

Any calculator is permitted

No handwritten notes are permitted

No dictionaries are permitted

| ADDITIONAL AUTHORISED MATERIALS | EXAMINATION MATERIALS TO BE SUPPLIED |
|---|---|
| Lecture Textbook/s (Annotated Permitted)<br>Fundamentals of Machine Component Design, 5th Edition, Wiley. | 1 x 20 Page Book |

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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**1.** Fig. 1 shows a countershaft with helical gear (*B*), bevel gear (*D*), and two supporting bearings (*A* and *C*). Loads acting on the bevel gear are known. Forces on the helical gears can be determined. Shaft dimensions are known. All shoulder fillets have a radius of 5 mm. Only bearing *A* takes thrust. The shaft rotates at 1000 rpm and is made of hardened steel having known values of $S_u$ and $S_y$. All important surfaces are finished by grinding.

(a) Draw load, shear force, and bending moment diagrams for the shaft in the *xy* and *xz* planes. Also draw diagrams showing the intensity of the axial force and torque along the length of the shaft.
(b) Calculate the forces at the bearings *A* and *C*.
(c) Select a suitable bearing at C for this shaft.

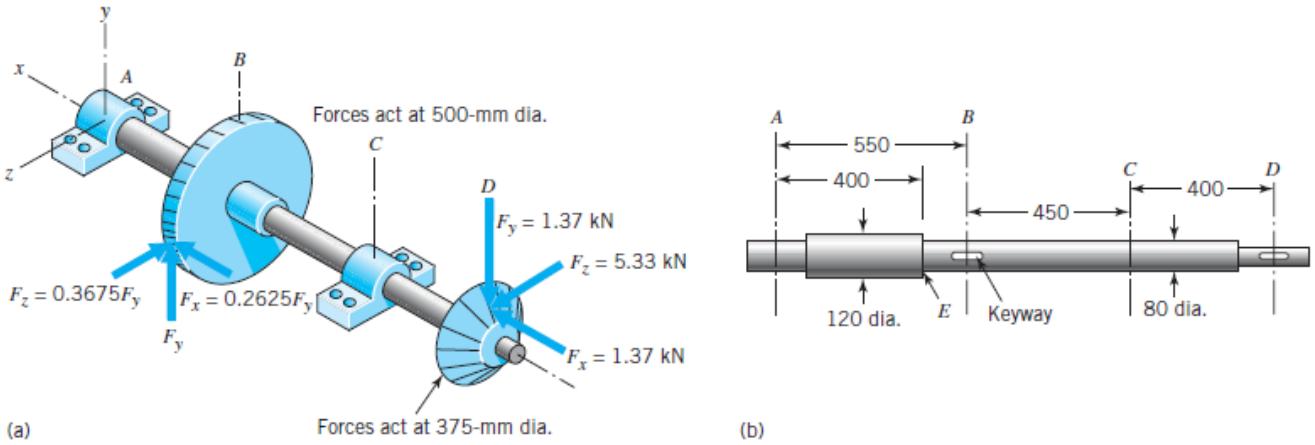


**Fig.1** Countershaft with helical gear (B) and bevel gear (D) (all dimensions in mm unless specified) (ref: Fundamentals of Machine Component Design, 5th Edition, Wiley.).

**2.** The four helical gears shown in Fig. 2 have a module in the normal plane of 4 mm and a pressure angle in the normal plane of 0.35 rad. The motor shaft rotates 550 rpm and transmits 20 kW. Other data are on the drawing.

(a) What is the speed ratio between the motor (input) and output shafts?
(b) Determine all force components that the 20-tooth pinion applies to the 50-tooth gear. Make a sketch showing these forces applied to the gear.
(c) The same as part (b), except for the force components that the 50-tooth gear exerts on the 25-tooth pinion.

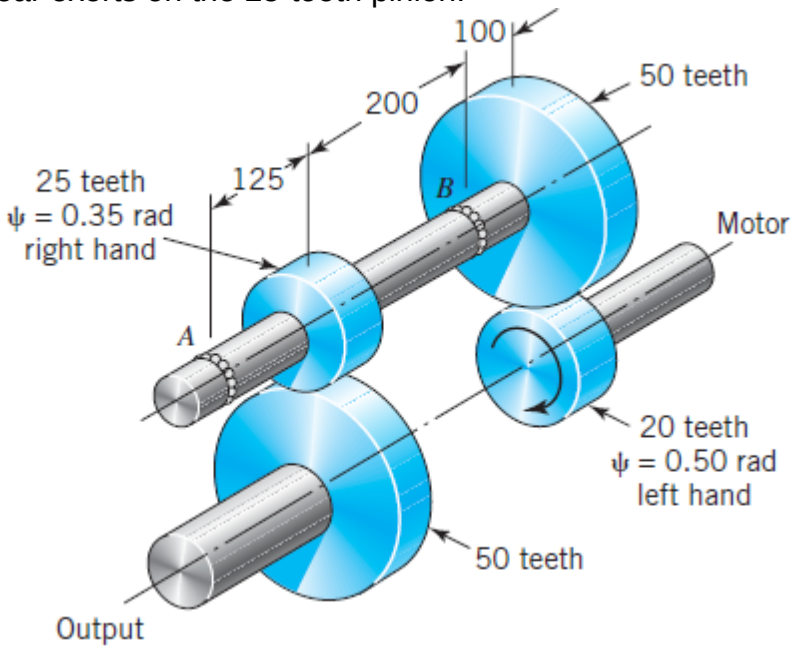


**Fig.2** Helical gear assembly (ref: Fundamentals of Machine Component Design, 5th Edition, Wiley.)

**3.** A pair of mating gears has 20° full-depth teeth with a module of 3.25mm. Both gear and pinion are made of steel heat-treated to 350 BHN, and both have a face width of 25mm. The teeth are cut with a top-quality hobbing operation. The pinion has 20 teeth and rotates 1100 rpm. It is mounted outboard on the shaft of an electric motor, and drives a 40-tooth gear that is positioned inboard on an accurately mounted blower shaft. The design life corresponds to 5 years of 60 hours/week, 50 weeks/year operation. Using a reliability of 99% and a safety factor of 1.5, estimate the power that can be transmitted, based only on bending fatigue.

**4.** A differential band brake similar to the one shown in Fig.3 is being considered for use with a hoist drum. With the hoist operating at rated load, a brake torque of 4000 N.m is required to hold the drum from slipping. The brake is to be designed to slip at a 15 percent overload. Available space limits the cast-iron brake drum diameter to 650 mm, with brake band contact extending over an angle of 250°. Design values for the brake lining selected are f = 0.40, $p_{max}$ = 1.1 MPa.

(a) Determine forces P1 and P2 corresponding to maximum brake torque and select an appropriate value of brake band width.
(b) If distance a (Fig.3) is 120 mm, what value of distance s would enable the brake to be operated with a force F of 200 N at the end of a lever of length c = 650 mm?
(c) Using the linkage dimensions from part (b), what value of coefficient of friction would make the brake self-locking?

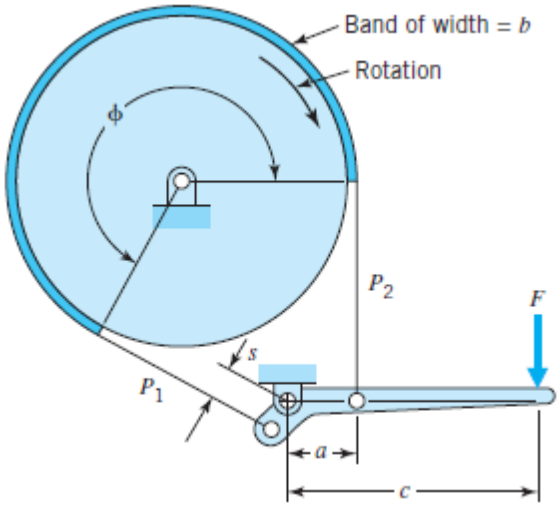


**Fig.3** Differential band brake (ref: Fundamentals of Machine Component Design, 5th Edition, Wiley.)

**5.** Two parallel shafts with 400mm centre distance are to be connected by module, m = 20mm, 20° spur gears providing a velocity ratio of 3.0. (a) Determine the pitch diameters and numbers of teeth in the pinion and gear. (b) Determine whether there will be interference when standard full-depth teeth are used. (c) Determine the contact ratio.